AIRS

Atmospheric Infrared Sounder

Quality Assessment Plan

Version 1.1
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Forward to Version 1.1

This update to the AIRS Quality Assessment Plan contains the following modifications from Version 1.0 delivered in March , 2000:

?? Lists of Figures and Tables are now included.

?? The opening part of the Introduction has been re-written.

?? The processing software is now in Version 2.0. This is reflected in the Processing File Descriptions in Section 1.1.1. Updated versions of the supporting documents are listed in Section 1.1.2.

?? All references to the Processing File Descriptions now refer to Section 1.1.1 where current and future modifications will updated.

?? The final sentence mentioning Product Specific Attributes in Section 1.3.1 was added.

?? The opening paragraphs of Section 5 were re-written to make it more relevant to the AIRS processing.

?? The number of Product-Specific Attributes has been reduced. They are listed in Appendix A.

?? Some of the Product-Specific Attributes will be used to trigger automatic notification of the AIRS Science Team. These are underscored in the tables in Appendix A.

?? Appendix A of Version 1.0 of this plan distinguished between 'QA-relevant' and 'general' Product Specific Attributes. This distinction is arbitrary so is not used in this document.

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Introduction

The major change to this document from Version 1.0 is an updated list of Product-Specific Attributes contained in Appendix A. Other changes are listed in the Forward to this document.

This plan describes the quality assessment (QA) processes and components for the Atmospheric Infrared Sounder (AIRS) Product Generation System (PGS). Its intended audience is AIRS, DAAC and ECS QA personnel, AIRS operations planning personnel, and potential users of AIRS data products, including the AIRS Science Team and the science community at large.

This document does not contain an exhaustive list of QA parameters. All QA parameters are listed in the Processing Files Description (see Supporting Documents below) as part of a complete list of AIRS output parameters. (It is conceptually difficult to separate QA from many other indicators such as instrument state). A complete list of AIRS Product-Specific Attributes is defined in Appendix A of this Plan. These reflect changes made with Version 2.0 of the PGE.

Later versions of this document will describe in greater detail the Manual QA activities of both the Team Leader Science Computing Facility (TLSCF) and the DAAC.

1.1. Supporting Documents

The documents listed below with JPL document numbers are available online via the search engine at http://airs-lib.jpl.nasa.gov/ .

1.1.1. The Processing File Description

The Products Specific Attributes are synopses of the Core Metadata found in the AIRS products. All currently defined Quality Assessment parameters associated with the AIRS instrument suite and the subsequent algorithms are included in:

AIRS Version 2.0 Processing Files Description, Version 4.0, August, 2000. JPL D-19555.

This is the most important supporting document for AIRS Quality Assessment, as it is the master list of all AIRS parameters, including QA data. Updates to QA parameters will be reflected as changes in these lists. The documents contains the following Appendices:

A1-1. L1A AIRS Science Interface Specification
A1-2. L1A AIRS Calibration Interface Specification
A1-3. L1A AIRS QA Subset Interface Specification
A1-4. L1A VIS Science Interface Specification
A1-5. L1A VIS Calibration Interface Specification
A1-6. L1A AMSU Interface Specification
A1-7. L1A HSB Interface Specification
A1-8. L1B AIRS Science Interface Specification

A1-9. L1B AIRS QA Interface Specification
A1-10. L1B AIRS Browse Subset Interface Specification
A1-11. L1B VIS Science Interface Specification
A1-12. L1B VIS QA Interface Specification
A1-13. L1B AMSU Interface Specification
A1-14. L1B HSB Interface Specification
A1-15. L2 Standard Atmospheric/Surface Product Interface Specification
A1-16. L2 Standard Cloud-Cleared Radiance Product Interface Specification
A1-17. L2 Support Atmospheric/Surface Product Interface Specification
A1-18. L2 Retrieval Browse Subset Interface Specification
A1-19. L2 Cloud-Cleared Browse Subset Interface Specification

Each of these Appendices lists QA parameters.

1.1.2. Other Supporting Documents

The AIRS Validation Plan and the Algorithm Theoretical Basis documents are currently under review.

The updated AIRS Validation Plan is:

The AIRS Team Science Data Validation Plan, Version 2.1.1, JPL D-16822, June 2000.

The original Validation Plan is:

AIRS Team Science Data Validation Plan, Core Products, JPL D-16822, Version 1.2, August 15, 1997

Many of the AIRS products are described in:

AIRS Science and Measurement Requirements Document, JPL D-6665 Rev 1 September 1991 AIRS Brochure

The AIRS calibration activities are detailed in:

AIRS Instrument Calibration Plan, JPL D-16821, Preliminary, October 14, 1997

The Algorithm Theoretical Basis Documents describe detailed operations of the processing algorithms. Currently under review, they are:

AIRS Algorithm Theoretical Basis Document, Level 1B, Part 1: Infrared Spectrometer, JPL D-17003, Version 2.0, January 4, 1999

AIRS Algorithm Theoretical Basis Document, Level 1B, Part 2: Visible/Near-Infrared Channels JPL D-17004, Version 2, January 4, 1999

AIRS Project Algorithm Theoretical Basis Document, Level 1b, Part 2: Microwave Instruments , JPL D-17005, Version 1.2, November 15, 1996

AIRS Algorithm Theoretical Basis Document, AIRS-Team Unified Retrieval For Core Products, Level 2, Version 2.0, December 15, 1999

Many references are made in this and earlier versions of this document to the ASTER QA Plan:

ASTER Higher Level Data Product Quality Assessment Plan, Version 2.0, JPL D-13841, October 18, 1999.

1.2. The AIRS Data Products

The AIRS data products are described in detail in the ATBD listed above. The AIRS instrument suite consists of four instruments: an infrared spectrometer, two microwave radiometers, and a visible / near IR imager.

The AIRS products are of four types:

?? *Level 0:* Instrument packets. L0 products have no associated QA quantities.

?? *Level 1A:* Geolocated radiance in counts, with a 14-bit dynamic range. L1A QA primarily describes the instrument state.

?? *Level 1B:* Calibrated radiance in physical units. L1B QA mainly pertains to the calibration process.

?? *Level 2:* Retrieved geophysical quantities. The software to determine atmospheric state from the L1B quantities is complex, so most QA parameters describe L2 processing.

Figure 1 shows the flow of data through the AIRS processing software. Each processing step creates associated QA parameters. The QA quantities for Level 1A through Level 2 are listed in AIRS Version 1.5 Processing Files Description.

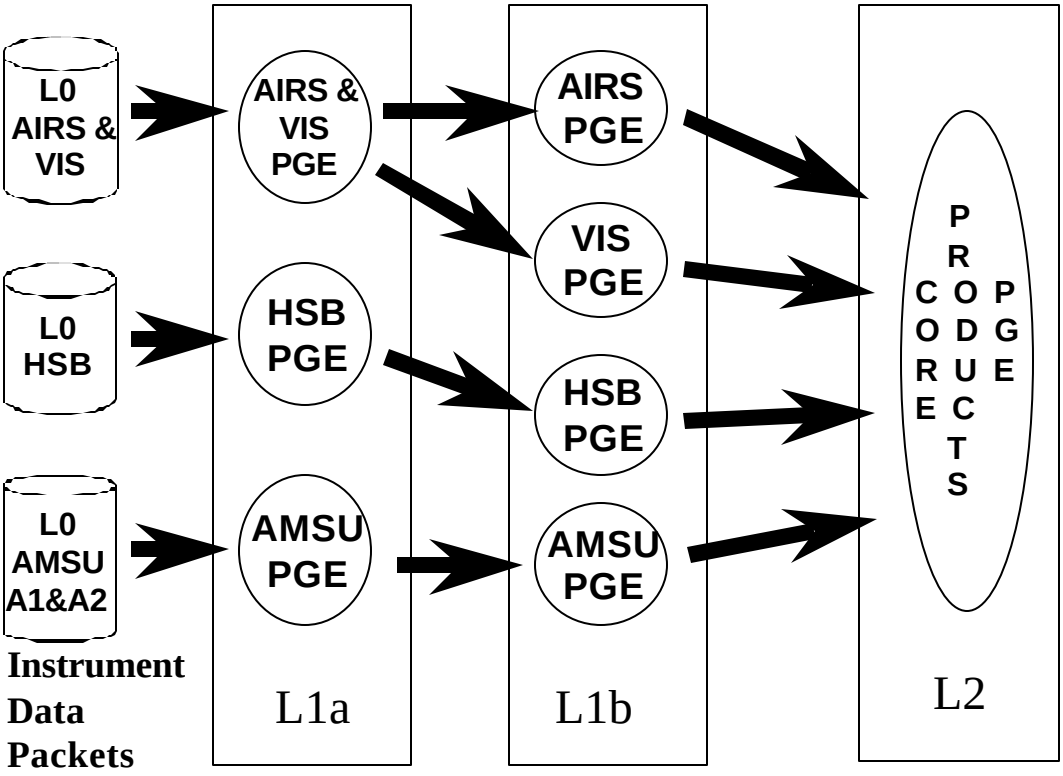

Figure 1 Overview of AIRS processing flow.

1.3. Types of AIRS Quality Assessment

The three types of AIRS QA are described here. The responsibilities for different data types and the data flow are described in later sections.

1.3.1. Automatic QA

Automatic QA is performed within the product generation software. In the course of data product generation, QA parameters are calculated and QA results are reported. Because this QA information is calculated and collected without user intervention, it is referred to as automatic QA.

During automatic QA, a variety of summary statistics are calculated which provide insight into product quality. If these summary statistics indicate a quality problem, a message is generated in the log, the product is flagged as bad, and QA personnel are notified that Special QA is required. The Product Specific Attributes that will trigger automatic notification are underscored in Appendix A.

1.3.2. Special QA

Special QA is performed by a human operator at the DAAC and the TLSCF. If automatic QA indicates that a product is bad, the DAAC first checks to see if there was some type of DAAC operational problem. If so, the problem is corrected and the product is re-generated. If no operational problem is found, manual QA is performed at the AIRS

Team Leader Science Computing Facility (TLSCF) to determine the problem and whether it can be corrected. During manual QA the archived logs may be used as ancillary information, along with other metadata. Identification and correction activities conducted within investigative QA are also recorded for future reference. Once these activities have been completed, the data product in question is marked as either good or bad.

1.3.3. Routine QA

Routine QA is manual QA performed at the TLSCF. The normal data product stream will be sampled daily to provide an additional check on data product quality. Up to 10% of the daily granule production will be examined, with sampling criteria supplied by the AIRS Science Team.

Granules are formally defined as the smallest aggregation of data that is independently managed (i.e., described, inventoried, retrievable.) An AIRS granule is defined as 6 minutes of data, and contains 45 AMSU scanlines.

1.4. Densities of QA Information

The QA information is defined at the several densities. Many quantities are defined at granule density. (A granule contains six minutes in time, or 45 along-track by 30 cross-track AMSU footprints). Other quantities are defined once per scanline, or once per instrument footprint.

QA parameters at granule, scanset and footprint densities are described in the AIRS Version 1.5 Processing Files Description (or appropriate updated document).

1.4.1. Product-Specific Attributes

Product-Specific Attributes (PSAs) are defined at the data granule level. A proposed set of AIRS PSAs is listed in Appendix A.

1.4.2. Level 1 QA Information

The density of QA information for Level 1A and Level 1B data will correspond to the size of packets received and the frequency of radiance calibration. This density is per scanline for AMSU and HSB, and per AIRS footprint for AIRS/VIS. (The AIRS and HSB instruments scan at thrice the density of AMSU. This gives nine AIRS or HSB footprints per 45 km diameter AMSU footprint. The VIS observation overlay all observation on a roughly 2 km grid).

This QA information will be part of the Level 1 data products. In addition, granule-level summaries will track variations in engineering data and counts of problems at the packet level. Some of this information will reside in granule-level metadata, and some of these are proposed as Product-Specific Attributes. Both per-packet QA and

summaries will also be available as separate QA subset products. The TLSCF will subscribe to all subset products and use them for routine manual QA.

1.4.3. Level 2 QA Information

The AIRS Level 2 algorithm operates on a collection of data. Level 2 QA is created at the density of the retrieval footprints, or a single AMSU scanset. The quantities are somewhat analogous the 'data planes' defined for other EOS instruments. As with Level 1 quantities, summary statistics will be created from the Level 2 QA fields. Some of these summaries are being proposed as Product Specific Attributes (see Appendix A).

1.4.4. Uncertainty Estimation

A prime objective of the AIRS science team is to provide numerical uncertainty estimates for every product. Some of these estimates will be static, calculated once at the start of the mission based on instrument testing or component specifications. Other uncertainty estimates will be refined based on the data received. The primary goal of AIRS validation activities is the estimation of uncertainties for all Level 2 quantities. Reaching this goal will require validating many of the Level 1A and 1B quantities used to derive the Level 2 fields.

Uncertainty estimates are a QA product and used by the community to know the accuracy of the results. They are also useful for routine manual QA at the TLSCF, since an increase in measurement uncertainty may indicate an instrument or algorithm problem.

2. Roles and Responsibilities

AIRS QA responsibilities will be shared among algorithm developers, DAAC personnel, and TLSCF personnel. This section defines the responsibilities of each.

2.1. Algorithm and Software Developers

The algorithm developers are responsible for the definition and implementation of QA parameters within the AIRS processing software.

2.2. DAAC

DAAC responsibilities for AIRS QA include:

?? Evaluating the operational success of the data generation process.

?? Initial evaluation of PGE failures to evaluate possible causes. AIRS data processing has been divided into a number of processing modules called Product Generation Executives (PGEs). Each PGE will generate one or more of the AIRS standard products.

?? For problems deemed operational, collecting or identifying log files and granules necessary for TLSCF personnel to continue troubleshooting.

?? Supporting AIRS quality problems reported by users via the DAAC's trouble-ticketing system and User Services and coordinating these problems with the TLSCF.

?? Ensuring the integrity of the data products and metadata, i.e., that data are not corrupted in the transfer, retrieval, or archival processes.

?? Communicating possible quality problems to the TLSCF.

?? Supporting ECS subscription services so that AIRS Science Team personnel can order and receive granules that require additional QA.

S*ubscriptions* permit users to register their interest in changes to and events associated with data products. For example, TLSCF QA personnel may register a subscription to be notified whenever a specific data product flag is set to Bad. The granule that triggered the flag will be made available to TLSCF QA staff for ftp pull or "pushed" by the DAAC via ftp to a specified remote directory at the TLSCF (based upon system functionality at the time.)

2.3. TLSCF

TLSCF responsibilities for AIRS QA include:

- Ensuring the scientific integrity of AIRS data products. While granules may arrive from the DAAC with no operational errors, the AIRS Science team evaluates them for acceptance based on both qualitative and quantitative examinations.
- Investigating possible science-related problems. By determining the cause of the out-of-range QA statistics, TLSCF personnel may lay the groundwork for solving and correcting these problems.
- Interacting with DAAC personnel. Evaluation of data products and investigation of problems may require setting subscriptions, retrieving granules from DAAC servers, and working with DAAC personnel to retrieve and understand DAAC processing logs.
- Interacting with algorithm developers from the AIRS Science Team. Evaluation of data products and investigation of problems may also require discussions with the algorithm developers to understand an algorithm's behavior or to help the developer formulate changes to the algorithm to prevent future occurrences of bad data.
- Interacting with the instrument team and the AIRS Science Team regarding instrument status and instrument-related problems. AIRS QA may reveal problems related to instrument behavior. Any such problems discovered would require discussions with the instrument team and the AIRS Science Team to help characterize the nature of the problem and its potential effects on the operation of the instrument and on data processing. In addition, the TLSCF may be able to offer advice to the instrument team in setting the instrument into its optimal operating configuration.

3. Overall Flow

The overall flow of QA information is similar to that for ASTER. The figure is taken from the ASTER QA Plan.

Figure 2 provides a graphical overview of the AIRS QA scenario. Each step in the scenario has been numbered, and these numbers will be referred to as a guide throughout this section. Beginning at the upper left with Step 1, data product generation is requested via a Data Processing Request (DPR). Depending on the data product requested, the appropriate Product Generation Executive (PGE) or chain of PGEs is initiated to generate the product.

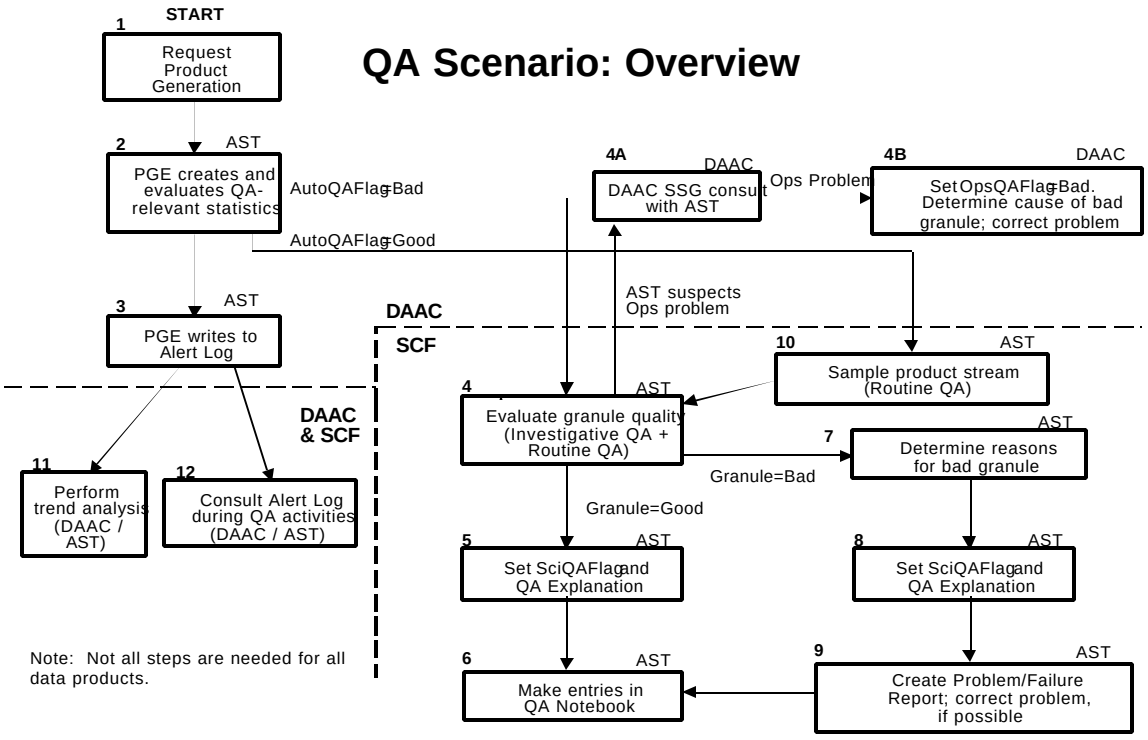

Figure 2 Overview of QA Scenario, from the ASTER QA Plan.

3.1. Automatic QA

In the course of data production, QA-relevant statistics for the footprint, scan, and granule are calculated within the PGEs (Step 2). Summary data at this step are stored in product-specific attributes (PSAs), a metadata type that provides the means to define and store instrument-team-defined metadata information. The contents of these PSAs is sent

to a temporary QA Subset file via a PGE call (Step 3). If the product passes automatic QA, the PGE sets the AutoQAFlag to Good, updates the header, and proceeds to the next data product in the queue.

3.2. Manual QA at the DAAC

If a granule fails automatic QA, the PGE sets the AutoQAFlag to Bad. DAAC personnel will submit subscriptions to be notified when this flag is set to Bad. DAAC personnel then retrieve the granule and evaluate the operational success of the granule processing. This evaluation process is called DAAC investigative QA. DAAC investigative QA determines whether error messages in the Report Log and Status Log were generated due to procedural and/or operational errors at the DAAC (Step 4). For instance, an incorrect input file may have been queued for processing (e.g., a parameter file for the previous day's data). If such a problem is found, the OpsQAFlag is set to Bad and DAAC personnel determine the cause of this problem and correct the error (Step 5).

If a large number of granules from a single PGE are identified as Bad, DAAC personnel will perform investigative QA on a representative sample of the granules in an attempt to identify a common cause for the problem. If the cause of the widespread problem is not readily diagnosed, it will be referred to TLSCF QA personnel.

If no operational problem is discovered, the OpsQAFlag is set to Good and e-mail notification is sent to TLSCF personnel that the granule is ready for further QA (Step 6). E-mail notification will be sent approximately once per day and will include all affected granules as well as their location at the DAAC (e.g., a specific subdirectory on a specific DAAC machine).

3.3. Manual QA at the TLSCF - Investigative

After TLSCF personnel have been notified that a granule is ready for further QA, they may then retrieve the granule from the specified location and evaluate its quality as part of TLSCF investigative QA (Step 7). Retrieval will be completed using ftp pull. During investigative QA, TLSCF personnel review log files and QA Subset products to see why the granule failed automatic QA and review the granule visually to help determine its usefulness to the AIRS Science Team. Details of product-specific manual QA are given in Appendix E.

If the granule fails TLSCF investigative QA, the SciQAFlag is set to Bad and the granule is evaluated to determine the cause(s) of the failure (Step 10). There is no set formula for determining these causes, and problem solving is handled on a case-by-case basis. In addition to the experience of the TLSCF personnel, interaction with AIRS Science Team members, instrument team members, algorithm developers, and PGS software developers may be necessary to complete TLSCF investigative QA.

Once the causes have been identified, the Science QA Explanation field is updated using the ECS-provided Metadata Update Tool to explain why particular values were set for the SciQAFlag metadata (Step 11).

A description of each step performed during investigative QA will be captured in an entry to the QA Notebook (QANB). The QANB is a file that collects specific QA activities and comments in much the same way an experimental scientist would collect information in a laboratory notebook in their work area (Step 9). For example, if a batch of products was created using the wrong calibration files, and reprocessing was requested to correct the problem, QA personnel would compile this information to maintain a record of exactly what they did.

The purpose of the QANB is to capture exactly what was done during investigative QA so that it can be re-visited if necessary, and to provide a sequential summary of QA problems that may be useful for trend analysis (Step 14). The QANB is an ASCII file produced by TLSCF QA personnel and managed and maintained at the TLSCF. However, the QA Notebook will be available to all QA and AIRS Science Team personnel. Note that the QANB is only one component of QA trend analysis, which is discussed in more detail in Section 6.0.

When needed for TLSCF investigative QA, the QA Subset product and log files are retrieved from a designated directory on a designated machine at the DAAC (Step 15).

Problems discovered during TLSCF investigative QA will be captured in a Problem/Failure Report (PFR), which allows TLSCF QA personnel to formally document the problem (Step 12). PFRs forms will be hard copy or web-based. The PFR may lead directly to a DPR to create a corrected granule or to the implementation of operational changes to prevent future occurrences of the problem.

If the granule passes TLSCF investigative QA, the SciQAFlag is set to Good, the QA Explanation field is updated using the Metadata Update Tool and explanatory text is provided for the QA Notebook, in the same way as was done for failed granules (Step 8).

3.4. Manual QA at the TLSCF - Routine

Even if no granules are marked for investigative QA by the automatic QA process, some percentage of the granules in the production stream will undergo manual QA (Step 13). This review serves to provide an additional check on the production process and is called TLSCF routine QA. The size of granules sampled routinely will not exceed 10% of the total volume of data processed.

The AIRS Science Team has determined relative sampling rates for each data product based on algorithm complexity and the likelihood of problems with the algorithm. Section 7 contains information about data stream sampling. If necessary, these sampling rates will be updated after launch when more experience is gained in performing QA at the TLSCF.

Based on the AIRS Science Team sampling guidelines, the TLSCF QA Engineer submits queries to EOSDIS approximately daily and orders those granules meeting the query criteria. Typical search parameters might include latitude/longitude of the target, day

and/or time of acquisition, and day and/or time of processing. These granules are then evaluated using standard review procedures. TLSCF QA personnel may also develop product-specific procedures in conjunction with the algorithm developers. The results of routine QA at the TLSCF are entered in the QANB.

Delivery to the TLSCF will be made via ftp or via digital media. Media shipment schedules are TBD, with daily or weekly shipment most probable.

4. Trend Analysis

Trend analysis is the process of comparing daily granules and metadata to similar datasets from earlier in the mission. This type of analysis is used primarily for troubleshooting during manual QA, but may also be used to track behavior of the PM-1 platform, the AIRS instrument, or a PGE throughout the course of the mission.

Trend analyses by DAAC and TLSCF personnel will rely on reviews of the summary statistics, the log files, and the QANB (discussed in detail in Sections 5.1.1 and 5.3, respectively, and in Appendix A.) Summary statistics also provide key indicators of instrument and algorithm performance. The QANB provides a sequential summary of QA activities at the TLSCF performed.

5. Alerts

Many part of this section are slight modifications of the ASTER QA Plan.

In the course of data product generation, QA-relevant summary statistics are calculated within the PGEs for each granule. These summary statistics include values such as the percent of bad spectra in a granule. When any of these summary statistics is outside their assigned ranges, an "alert" is raised, causing alert information to be sent to an Alert Log, which is permanently archived at the DAAC for future reference. There will be one Alert Log for each AIRS data product. Alert information is also written to the data product header for the end-user's reference.

This following section details how alerts are calculated, collected and archived for AIRS data products.

5.1. Alert Handling Scenario

The scenario for calculating, storing and evaluating summary statistics and collecting alerts in the Alert Log is presented in the following steps. It is important to note that the terms “permanent” and “temporary” are used generically to refer to a saved file and to an interim file, respectively, and do not imply the ECS-specific usage of these terms.

1) During product generation, the value for each summary statistic is calculated. Each summary statistic is a Product-Specific Attribute and is reported as granule-level metadata, regardless of its value.

2) Each summary statistic is compared to its valid range. If the statistic is outside the valid range then the associated alert is triggered. If a "critical alert" occurs, the granule being processed fails automatic QA, the granule is designated for manual QA, and the alert is archived. "Non-critical alerts" are archived, but no specific QA action is prescribed. Valid ranges for summary statistics and the critical and non-critical alerts for each product are defined by the algorithm developers and stored in a look-up table, where they are adjustable, as necessary.

3) Each product will have a PSA called QASummaryofAlerts. This attribute consists of a text field containing a table summarizing all the alerts for the granule. Each time an alert is triggered another entry is made in the table. The exact contents is TBD.

4) The table stored in QASummaryofAlerts is written to two places:

a) The product header

b) In a temporary file associated with the current instance of the PGE

5) The number of critical alerts and the number of non-critical alerts are stored as metadata in the Product-Specific Attributes TBD.

6) A temporary alert file is created by the PGE whenever one or more alerts are triggered during generation of a granule. Later, these temporary files are turned into permanent files which are archived. When this file is opened a standard set of information is first written to it to identify the source of the alerts. This standard set is TBD but will contain items such as:

- Timestamp
- Product name
- PGE Name
- Algorithm version
- Software version
- Granule identifier

After this header section, the table stored in QASummaryofAlerts appears. If no alerts are generated, this file is not created.

7) Periodically (likely daily during the first months of AIRS operation, and weekly thereafter) a process is automatically started which concatenates all the temporary alert files into an Alert Log and then archives that file. The temporary files are either deleted or set to expire after an appropriate period.

6. Product-Specific Attributes

Product-Specific Attributes (PSAs) for AIRS products are defined in Appendix A. This list is intended to be all-inclusive, so it contains some quantities not usually considered to be QA parameter.

7. Level 1A Quality Assessment

The product components that serve as containers for AIRS QA information, as well as the contents of those containers are detailed in the AIRS Processing Files Description, JPL D-15783 (or appropriates updates to this list) listed in the Introduction. QA information appears in the data product metadata and AIRS has chosen to use product-specific attributes (PSAs) as the containers for that metadata. AIRS Per-Granule QA information is collected during data product generation, and that information is stored in QA products, which are linked to the science products.

7.1. Level 1A QA Approach

The Level 1A Quality Assessment fields primarily reflect conditions with the instruments. The Level 1A QA quantities are partly based upon Engineering Data from the instruments ?????

7.2. Level 1A QA Products

The Level 1A QA Products are defined in the AIRS 1.5 Processing Files Description. The most recent update is listed in the 'Supporting Documents' section of the Introduction.

7.3. Handling Bad and Suspect Level 1A Data

Level-1A missing data will be replaced with a flag value of -999. This includes the HSB 89 GHz channel, and any data for which the needed packet is missing.

Suspect data within a data product will not be replaced with cosmetic or marker values. This data may not be bad for all users or may still contain some scientifically useful information. In addition, suspect data will be needed to understand why the data are bad, possibly leading to algorithm improvements.

8. Level 1B Quality Assessment (ALSO NEED MW)

8.1. Level 1B QA Approach

Level 1B QA flags take one of five input values, corresponding to five different "alarm" states, abbreviated "ryGYR" (These five states are taken to be mutually exclusive):

Condition	Alarm	Status	Meaning
r	Alarm	Red, Low	Value much too low
Y	Warning	Yellow, Low	Value unexpectedly low
G	None	Green	Value within expectations
Y	Warning	Yellow, High	Value unexpectedly high
R	Alarm	Red, High	Value much too high

Table 1 Level 1A alert flag values.

8.2. Level 1B QA Quantities

The Level 1B QA Quantities are defined along with all other AIRS parameters in the document AIRS Version Processing Files Description listed in the Supporting Documents section of the Introduction. This and subsequent versions will be the master document for all AIRS products, and any changes –including QA parameters—will be reflected there.

8.3. Handling Bad and Suspect Level 1B Data

Level-1B missing data will be replaced with a flag value of –999.

9. Level 2 Quality Assessment

The first step in the Level 2 quality assessment procedure will be the generation of a set of parameters summarizing potential problems with the retrieval algorithm, and also any aspects of Level 1A and Level 1B QA affecting the retrieval. This require incorporating the control of Level 1 QA parameters within the currently existing retrieval scheme. This is currently ongoing. Level 2 QA processing will also require the manual and automatic evaluation of these parameters. The development of a system for parameter display and analysis is ongoing at the AIRS TLSCF.

The Level 2 QA approach is significantly different from those of Level 1A and Level 1B products. Level 2 retrieved quantities are best estimates of the state of the atmosphere, so variability in the retrieved quantities may be due to vagaries in atmospheric conditions as well as those of the very complex retrieval algorithm. In contrast, Level 1A quantities (engineering units and radiance counts) and Level 1B quantities (physical radiance) are more dependent upon conditions within the atmosphere or the instrument itself rather than the relatively simple associated algorithms. Level 1A and 1B QA summary statistics are generated for many quantities. Large amounts of summary statistics will not be generated as part of the Level 2 QA procedure. Instead, our intent is to define appropriate QA parameters to be used to diagnose the state of the

retrieval algorithm. Summary Level 2 QA statistics will be incorporated into the data validation process.

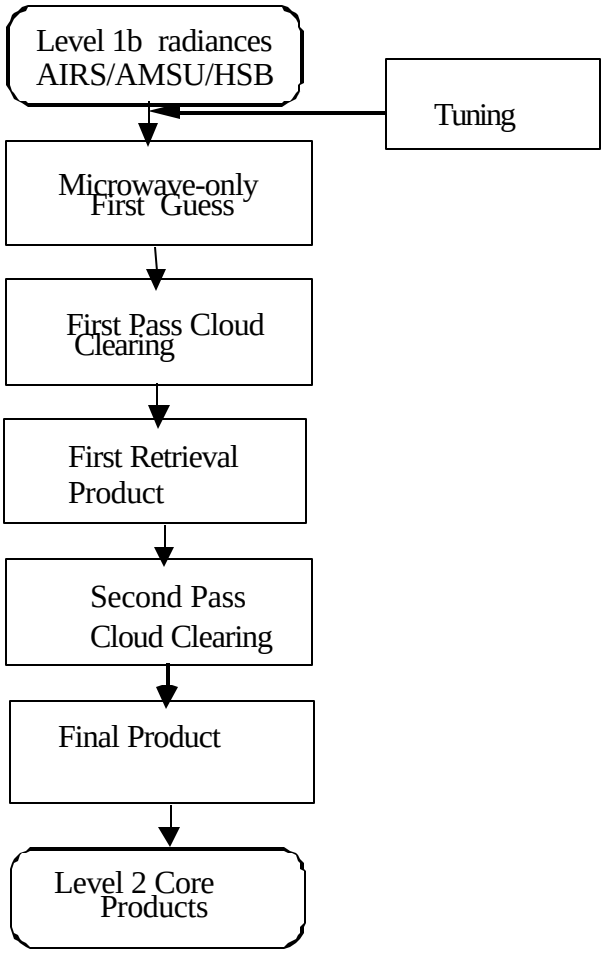

Figure 3 Level 2 data flow.

The flow of information with the retrieval algorithm is shown in Figure 3. The retrieval algorithm will likely fail under many conditions (some of which will not be anticipated prior to launch). In these cases it will be necessary to examine a large suite of intermediate retrieval quantities. For example, each of the retrieval steps boxed in Figure 3 will generate a suite of retrieval parameters. The generation and examination of these intermediate products will be another major aspect of the QA procedure. (The first is the monitoring of the QA flags described above). Because of the large data volume and complex analyses associated with the intermediate products, they will be produced only a small fraction of the time. The data files containing this large volume of intermediate results are known collectively as the AIRS QA Support Product. It will be generated and archived at the AIRS TLSCF.

It should be noted that the Quality Assessment procedure is not intended to provide a final evaluation of product geophysical significance. This is the goal of the data validation procedure detailed in the AIRS Validation Plan listed in the Introduction to this Document. Furthermore, Level 2 QA parameters are not error estimates, though error estimates will be examined as part of the overall QA process.

The fundamental granularity of the Level 2 data is the AMSU observing footprint, or the retrieval footprint. Each contains a single AMSU spectrum, two three-by-three grids of AIRS and HSB spectra, and four Visible-Near IR values sampled on a grid with 2.2 by 2.2 km resolution. A retrieval is performed at each of the AMSU observing footprints. Each retrieval footprint is 45 km across at nadir, and the scan swath is 30 retrieval footprints wide. This granularity is preserved in the Level 2 Quality Assessment procedure. Appendix A describes a prototype Level 2 QA indicator to be returned at each retrieval footprint. This indicator consists of a set of bits with default values of zero. Nonzero values of certain bits indicate a specific problem with part of the retrieval algorithm, e. g. first cloud clearing. Other bits are logical OR of the other bits, e. g., all flags for first cloud clearing. A single, most significant bit indicates a problem somewhere within the retrieval process for a given footprint. This hierarchy of indicators will simplify the search for retrieval problems.

In situations where retrieval problems are known or expected, intermediate Level 2 QA Support Products will be generated and examined.

9.1. Monitoring Processing Flow

Processing flow is indicated by several of the flags in the Level 2 QA Indicator in AIRS Processing Files Description, or its appropriately updated version listed in the Introduction to this document.

9.2. Processing Steps and Control Flow

The Level 2 QA indicator will provide information about the branching characteristics of algorithms used to generated the Level 2 products. It will provide an overview of the processing steps. In regions where the retrieval algorithm is known to be performing poorly the QA Support Products whose exact contents is TBD will provide addition diagnostic information. It is expected that the QA Support Products will be generated only a small fraction of the time because of their prohibitively large size.

9.3. Interfaces to Instrument and Level 1 Data

An important part of Level 2 Quality Assessment is the communication of QA information from lower levels. This will be accomplished by passing a select subset of information from lower levels to Level 2. These are listed in the Processing Files Description in the Introduction to this document.

9.4. Handling Bad and Suspect Level 2 Data

The retrieval algorithm will encounter difficulties of many different types because of data complexity and the wide range of conditions present in the atmosphere. We cannot anticipate what these problems will be. For this reason, the basic approach to AIRS Level 2 Quality Assessment is to provide information about the several different steps undertaken within the retrieval. This information is provided in the Level 2 QA indicator discussed above. Once a problem with the retrieval algorithm is suspected, the intermediate QA Support Products will be generated and examined at the TLSCF. These will provide detailed information about the retrieval procedure. Further QA information is provided by the error estimates associated with each retrieved field. Finally, the retrieved fields and Level 1 quantities themselves contain important Quality Assessment information. All these quantities will be useful in the definition of good, bad and suspect data.

A number of conditions will prevail where complete Level 2 retrievals cannot be performed. An example is missing input infrared spectra, so only a microwave retrieval will be performed. At such times missing values will be substituted with –9999. This value does not correspond to any physically realistic value in the Level 2 products. (Note that the standard error flag of -999, -888, etc. are reasonable values of 1000 mb geopotential height within strong storm systems.)

10. QA Data Volume

Because QA cannot be fully separated from all other AIRS data, its volume will not be estimated here.

Appendix A: Product-Specific Attributes

AIRS Product-Specific Attributes (PSAs) for AIRS products are tabulated below. Note that this list includes some non-QA parameters. Those PSAs designated for triggering of Automatic QA alerts are **Underscored**.

Table 2 ***Product-Specific Attributes for All Products***

Parameter Name	Variable Type	Descriptor
QASummaryofAlerts	Table	Tabulation of all alerts for this granule.
AutoQAFlag	Integer	Pass / Fail Automatic QA at DAAC.
OpsQAFlag	Integer	Pass / Fail Manual QA at DAAC.
ScienceQAFlag	Integer	Pass / Fail Manual QA at TLSCF.
QANumBadData	Integer	Number of footprints in granule that cannot be processed. The value -1 is used to indicate unknown value.
QANumSpecialData	Integer	Number of footprints in granule for which the instrument is in a special calibration mode. The value -1 is used to indicate unknown value.
QANumProcessData	Integer	Number of footprints in granule which are present and can be processed.
QANumMissingData	Integer	Number of footprints in granule with missing data.
NumLandSurface	Integer	Number of footprints within the granule with land fraction at or near 100%.
NumOceanSurface	Integer	Number of footprints within the granule with land fraction at or near 0%.
OrbitPath	Integer	Orbit number within the repeating set of 233 orbits.
AIRSGranuleNumber	Integer	Granule number within the set of 240 possible daily.
LonGranuleCen	Float	Longitude of the centroid of the granule in degrees.
LatGranuleCen	Float	Latitude of the centroid of the granule in degrees.
LocTimeGranuleCen	Float	Local time at the centroid of the granule in minutes from midnight.
NumScanLines	Integer	Corresponding to dimension GeoTrack, indicates size of data set in scan lines.
NumGeoQA	Integer	Number of footprints in granule with goelocation errors.
NumSunGlint	Integer	Number of footprints in granule with possible sun glint.
NumMoonInViewMW	Integer	Number of scanlines in granule with the moon in the Microwave space view.
NodeType	String	String denoting whether granule is completely 'Ascending', 'Descending', or transitional with value 'North' or 'South'.

ProductGenerationFacility	String	Location where this granule was processed. This will help mark granules not produced at the GDAAC. Valids to be the same as for ProcessingCenter.

Figure 3 ***Product-Specific Attributes for Clear Sky Conditions***

Parameter Name	Variable Type	Descriptor
NumVISDarkAMSUFOV	Integer	Number of AMSU footprints that are uniformly dark in the Level 1B Vis / NIR and are thus likely to be uniformly clear.
NumVISBrightAMSUFOV	Integer	Number of AMSU footprints that are uniformly bright in the L1B Vis / NIR and are thus likely to be uniformly cloudy.
NumLowCloudVis	Integer	Number of profiles in granule where Vis/NIR retrieval detects low clouds in all pixels.
NumCloudyVis	Integer	Number of AMSU footprints in granule that Vis/NIR retrieval classifies completely cloudy.
NumClearVis	Integer	Number of AMSU footprints in granule Vis/NIR retrieval classifies completely clear.
NumClearMW	Integer	Number of AMSU footprints in granule Microwave retrieval classifies completely clear.
NumClearIR	Integer	Number of AMSU footprints in granule Infrared retrieval classifies completely clear.

Table 3 ***Product-Specific Attributes for AIRS Level 1B Fields***

Parameter Name	Variable Type	Descriptor
NumPop	Integer	Number of popcorn events within granule, i.e., number of times that a set of AIRS channel has suffered a sudden discontinuity of dark current.
NumDCR	Integer	Number of times a Direct Current Restore was executed for any module in granule

Table 4 ***Product-Specific Attributes for AIRS and VIS Level 1A and 1B Fields***

Parameter Name	Variable Type	Descriptor
CalibrationMode	Logical	Comma delimited list of all special calibration modes employed within granule

Table 5 ***Product-Specific Attributes for VIS Level 1A and 1B Fields***

Parameter Name	Variable Type	Descriptor
PhotoCalibrationOn	Logical	Indicates whether photometric calibration source was turned on in the granule.

Table 6 ***Product-Specific Attributes for AIRS Level 1A Engineering Fields***

Parameter Name	Variable Type	Descriptor
EngDataFormatPacket1	Packet	Comma delimited list of all engineering data formats (EDFs) for flexible engineering packet #1 found in granule. The EDF specifies what information is included in a packet.
EngDataFormatPacket2	Packet	Comma delimited list of all engineering data formats (EDFs) for flexible engineering packet #2 found in granule. The EDF specifies what information is included in a packet.
UnProcessedEDF1	Packet	Comma delimited list of all engineering data formats (EDFs) for flexible engineering packet #1 found in granule but not allowed for by the current decommutation map. These packets cannot be processed.
UnProcessedEDF2	Packet	Comma delimited list of all engineering data formats (EDFs) for flexible engineering packet #2 found in granule but not allowed for by the current decommutation map. These packets cannot be processed.

Table 7 ***Product-Specific Attributes for Match-up Files***

Parameter Name	Variable Type	Descriptor
NumTruthMatches	Integer	Number of truth observations with at least one AMSU footprint of AIRS Product satisfying the collocation test.
NumRetMatches	Integer	Number of retrievals matched with truth.

Table 8 ***Product-Specific Attributes for AIRS Level 2 Fields***

Parameter Name	Variable Type	Descriptor
VersionRetrieval	String	Version of the Total retrieval algorithm (VnnRxxx).
NumPrecipMW	Integer	Number of profiles in granule in which Microwave retrievals detects rain.
NumCloudIceMW	Integer	Number of profiles in granule in which Microwave retrievals detects ice (graupel).
NumBadL1BAMSU	Integer	Number of profiles in granule with bad AMSU-A Level 1B data.
NumBadL1BHSB	Integer	Number of profiles in granule with bad HSB Level 1B data.
NumBadL1BAIRS	Integer	Number of profiles in granule with bad AIRS Level 1B data.
NumBadL1BVis	Integer	Number of profiles in granule for which at least one Level 1B Vis/NIR radiance is bad.
NumBadL1B	Integer	Number of profiles in granule in which the Level 2 processing was not allowed due to bad Level 1B data.
NumNoPsurfGuess	Integer	Number of profiles in granule in which the surface pressure was estimated from climatology rather than forecast.
NumNoTuning	Integer	Number of profiles in granule with no tuning.
NumNoAngCorr	Integer	Number of profiles in granule with no angle correction.
NumFpe	Integer	Number of profiles in granule with floating point exception in retrieval.
NumVisInvalid	Integer	Number of profiles AIRS footprints with bad Vis / NIR Level 2 field(s).
NumMWStratIrRetOnly	Integer	Number of profiles in granule where microwave and stratospheric-IR stage succeeded but other infrared retrieval stage(s) failed.
NumRetInvalid	Integer	Number of profiles in granule where all retrieval stages (Microwave-Only, Initial, Final) failed.